17:20:12 OCA PAD INITIATION - PROJECT HEADER INFORMATION 03/24/88

Active

Project #: E-21-686
Center # : R6468-0A0

Cost share #:
Center shr #:

Rev #: 0
OCA file #:
Work type : RES
Document : GRANT
Contract entity: GTRC

Contract#: 1 R03 RR04311-01
Prime #:

Mod #:

Subprojects ? : N
Main project #:

Project unit: EE Unit code: 02.010.118
Project director(s):
BENKESER P J EE

Sponsor/division names: DHHS/PHS/NIH / NATL INSTITUTES OF HEALTH
Sponsor/division codes: 108 / 001

Award period: 880215 to 890214 (performance) 890514 (reports)

Sponsor amount	New this change	Total to date
Contract value	35,660.00	35,660.00
Funded	35,660.00	35,660.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: PHASED ARRAY TRANSDUCER FOR ULTRASONIC HYPERTHERMIA

PROJECT ADMINISTRATION DATA

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Sponsor technical contact

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Sponsor issuing office

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CONTRACTS MGT, DIV RESEARCH RESOURCES
NATIONAL INSTITUTES OF HEALTH
BETHESDA, MD 20892

Security class (U,C,S,TS) :
Defense priority rating : N/A
Equipment title vests with: Sponsor GIT X
EQUIPMENT CANNOT BE PURCHASED IN THE LAST 6 MONTHS OF THIS GRANT

ONR resident rep. is ACO (Y/N): N
supplemental sheet

Administrative comments -
INITIATION. THIS GRANT HAS BEEN AWARDED UNDER THE "SMALL GRANTS PROGRAM FOR PILOT STUDIES, BIOMEDICAL RESEARCH TECHNOLOGY PROGRAM"

E-21-686

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 12/13/89
Original Closeout Started ********

Project No. E-21-686 Center No. R6468-0A0

Project Director BENKESER P J School/Lab EE

Sponsor DHHS/PHS/NIH/NATL INSTITUTES OF HEALTH

Contract/Grant No. 1 R03 RR04311-01 Contract Entity GTRC

Prime Contract No.

Title PHASED ARRAY TRANSDUCER FOR ULTRASONIC HYPERTHERMIA

Effective Completion Date 890930 (Performance) 891230 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	891212
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Subproject Under Main Project No.

Continues Project No.

Distribution Required:	
Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
OCA/CSD	N
Other	N
	N

NOTE: Final Questionnaire sent to PDPI.

E-21-686

Phased Array Transducer for Ultrasonic Hyperthermia

Final Progress Report

Grant Number: 1 R03 RR04311-01

PI: Paul J. Benkeser
Georgia Institute of Technology
School of Electrical Engineering
Atlanta, GA 30332-0250

Introduction

The goal of this project was to develop a new design for an ultrasonic tapered phased array (TPA) transducer to determine its feasibility for use in hyperthermic treatment of deep-seated tumors. The specific aims were:

1. To theoretically determine the optimal design for the transducer to maximize its intensity gain through the use of an acoustic lens.
2. To experimentally verify the design by fabricating a scaled-down version of the transducer and measuring its acoustical output.
3. To identify the potential limitations of the transducer.

Each of these aims was accomplished during the project period. These accomplishments will be detailed in this report.

Results of Theoretical Analyses

The theoretical field patterns produced by a tapered phased array (see Fig. 1) with a lens were obtained through simple modifications of previously employed computer simulations [1]. Several single and multi-foci lens configurations were examined as illustrated in Fig. 2. The results of this theoretical analysis indicated that the multi-foci lens designs lacked sufficient intensity gain to preferentially heat the tumor [2]. These multi-foci lenses also reduced the flexibility of the tapered array since they restricted the number of y locations in which the foci could be placed.

The optimal lens design turned out to be a single foci lens which only softly focused the beam in the y-dimension. The soft focus allowed the beam to still be steered by several centimeters in the y direction by altering the driving frequency of the array, as illustrated in Figs. 3 and 4. The addition of this lens was found to increase the intensity gain of the array by approximately a factor of two. Based on previous calculations of the intensity gain required to preferentially heat deep-seated tumors [1], it is conservatively estimated that the largest tumor the TPA can treat is at least 4 cm in diameter.

Experimental Results

To experimentally verify the theoretical results, two tapered phased array transducers with both single and multi-foci lenses were fabricated. The lenses were fabricated from blocks of polystyrene. Polystyrene was chosen because: (1) its acoustical impedance is a relatively good match between water and the piezoceramic; (2) it is easy to mill; and (3) it is inexpensive and readily available from many sources. The arrays were fabricated using previously documented techniques [1]. One consisted of only 16 elements with an array aperture of approximately 4 cm by 10 cm, the other contained 48 elements with an array aperture of nearly 15 cm by 15 cm. The smaller array was used primarily to study initial lens designs since much less time was required to fabricate lenses for it compared to the large array. Lens designs which appeared promising, based upon the results obtained with the small array, were fabricated for the large array as well.

To test the array, a phased array controller was designed and constructed [3]. The primary components of this controller are shown in Fig. 5. The controller functions as one component of a closed loop hyperthermia system. The microcomputer serves as the central processing unit of the system responsible for sending phase, amplitude and frequency information to the controller to implement the desired focal pattern. The microcomputer can also receive the temperature data from a thermometry unit which can be used to implement a temperature control algorithm.

Experimental field patterns obtained from TPAs both with and without a lens, as shown in Fig. 6, confirmed that the lens narrows the beam profile in the electronically unfocused y-dimension. The arrays have not been driven at high acoustical power outputs to date. These high power measurements will be made after the construction of a force balance has been completed. This device will allow the acoustical power output of the array to be estimated.

Potential Limitations

This study has shown that the addition of an acoustic lens nearly doubles the intensity gain of the TPA. While this is a significant improvement, there often exists the need to treat tumors much larger than is possible with this design.

There is also a potential problem with the temperature rise in the lens due to the partial absorption of the ultrasound passing through it. The temperature rise effects the focussing properties of the lens. The lens will have to be cooled to prevent this from occurring. This can be accomplished by cooling the coupling media to draw heat away from the lens. The effectiveness of such a cooling technique will have to be experimentally evaluated.

REFERENCES

[1] P.J. Benkeser, L.A. Frizzell, K.B. Ocheltree, and C.A. Cain, "A tapered phased array ultrasound transducer for hyperthermia treatment," IEEE Trans. Ultrason., Ferro., Freq. Contr., vol. UFFC-34(4), pp. 446-453, 1987.

[2] P.J. Benkeser, Y.J. Yoon, T.L. Pao, and P.G. Barthe, "An improved ultrasonic tapered phased array applicator for hyperthermia," 9th Annual Meeting of the North American Hyperthermia Group, Seattle WA, March 1989.

[3] P.J. Benkeser and T.L. Pao, "An ultrasonic phased array controller for hyperthermia," Ultrasonics, (accepted for publication).

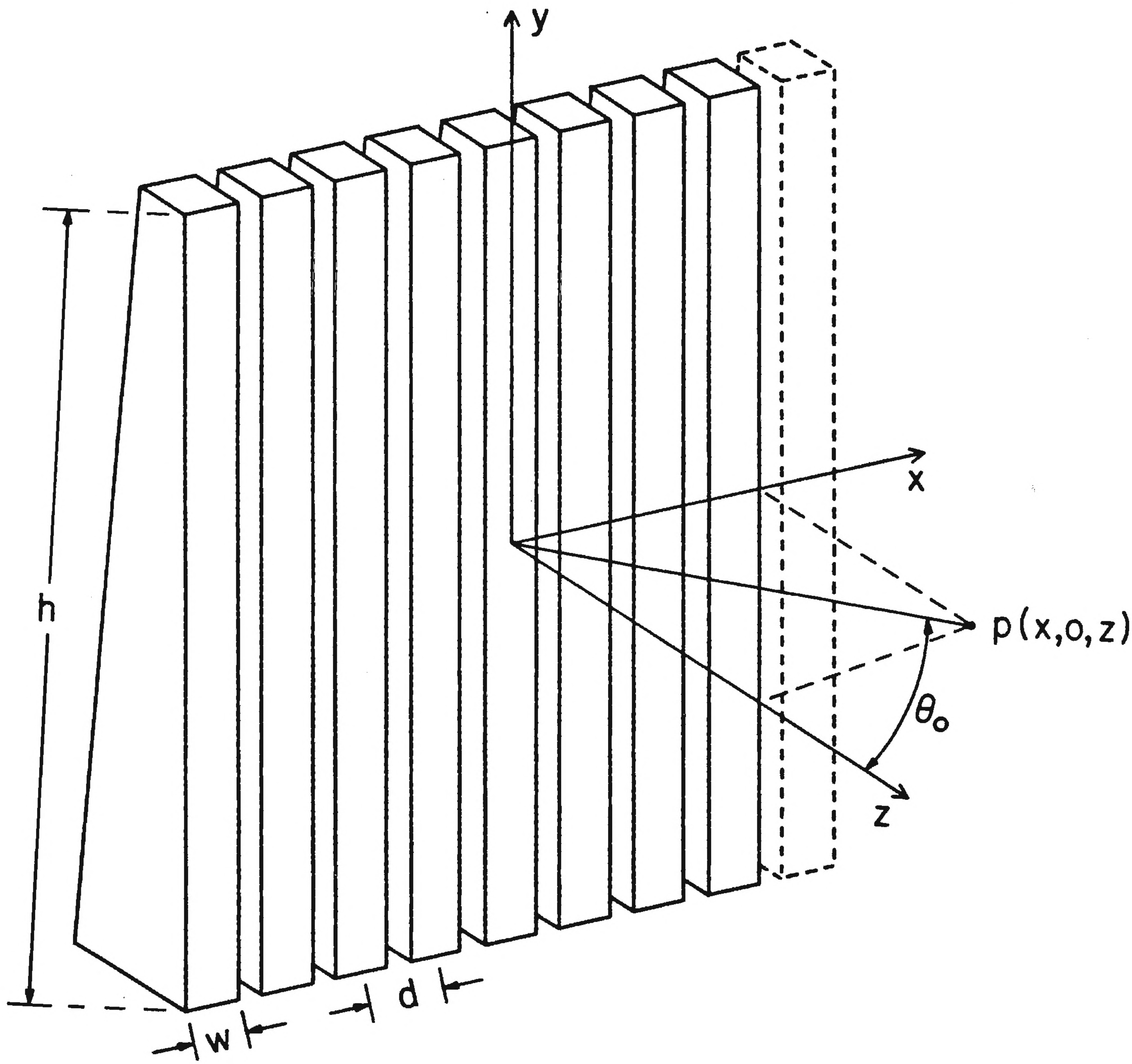

Figure 1. Tapered phased array

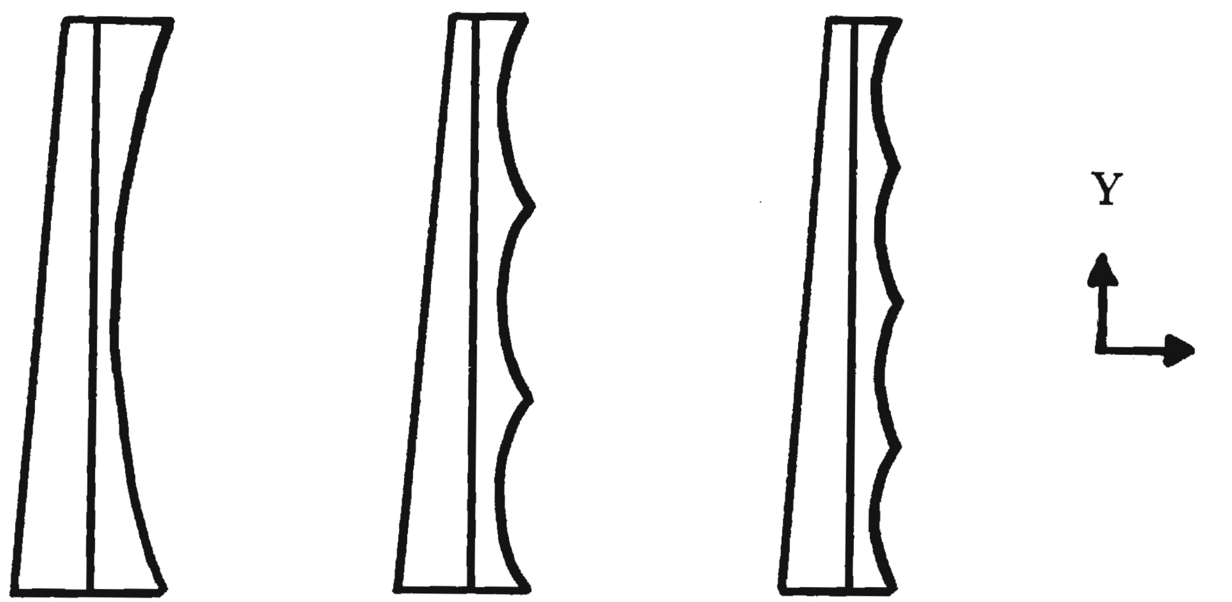

Figure 2. Lens designs investigated

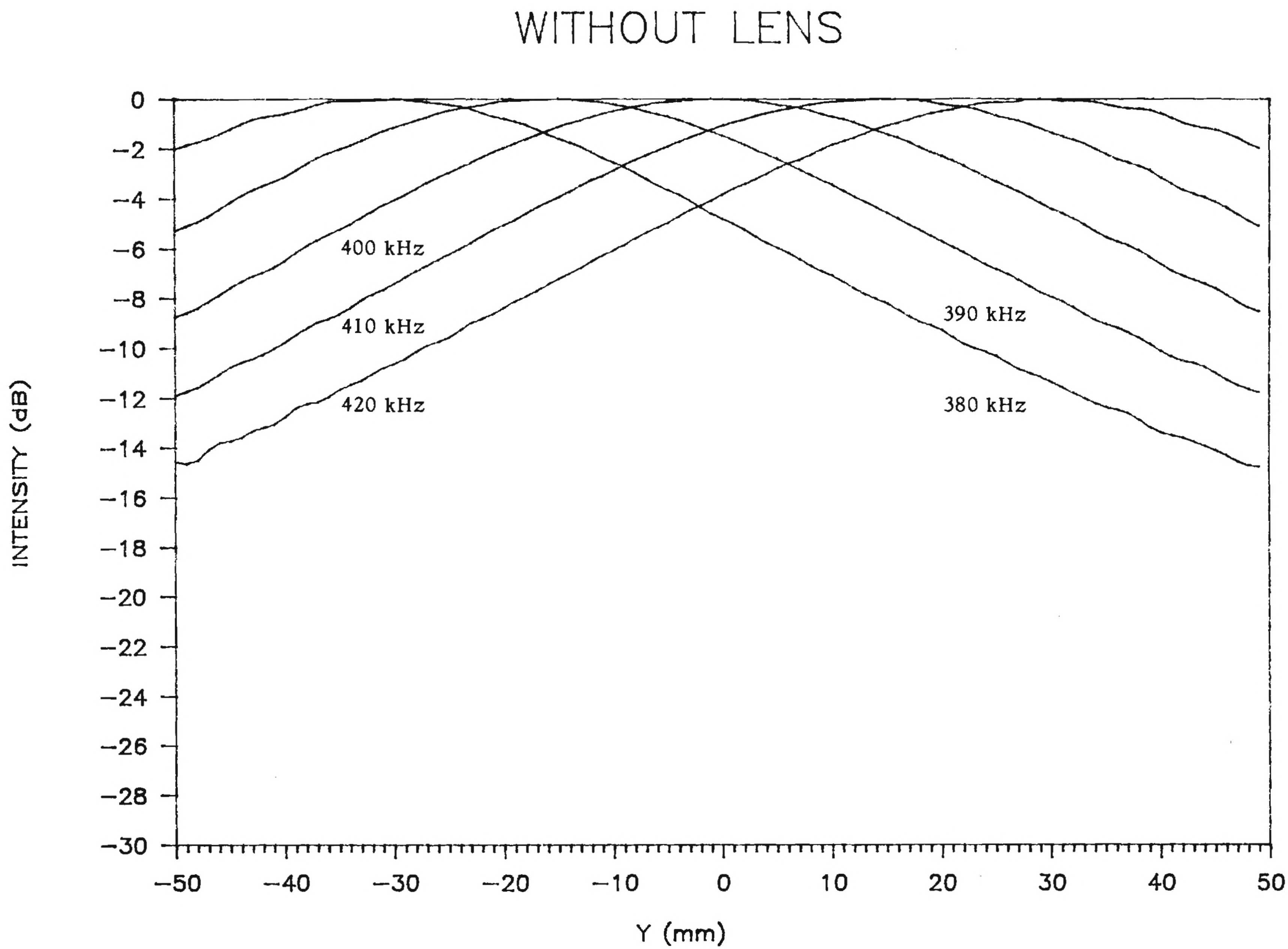

Figure 3. Theoretical beam profile of a 64 element TPA (no lens) with an aperture of 152 mm by 152 mm. The profile is at the electronic focal depth of z=50 mm.

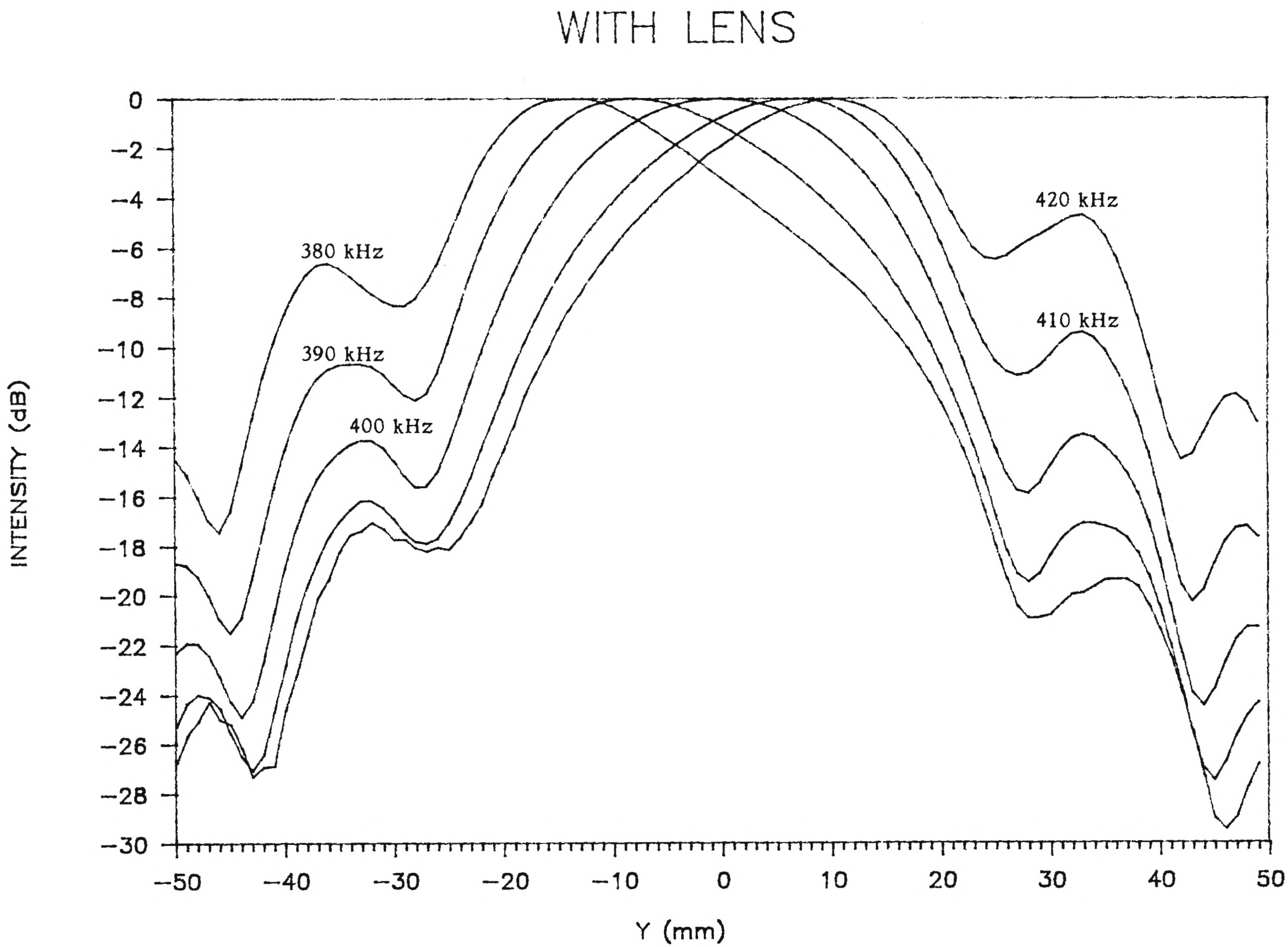

Figure 4. Theoretical beam profile of a 64 element TPA with an aperture of 152 mm by 152 mm and a 130 mm radius of curvature lens. The profile is at the electronic focal depth of z=50 mm.

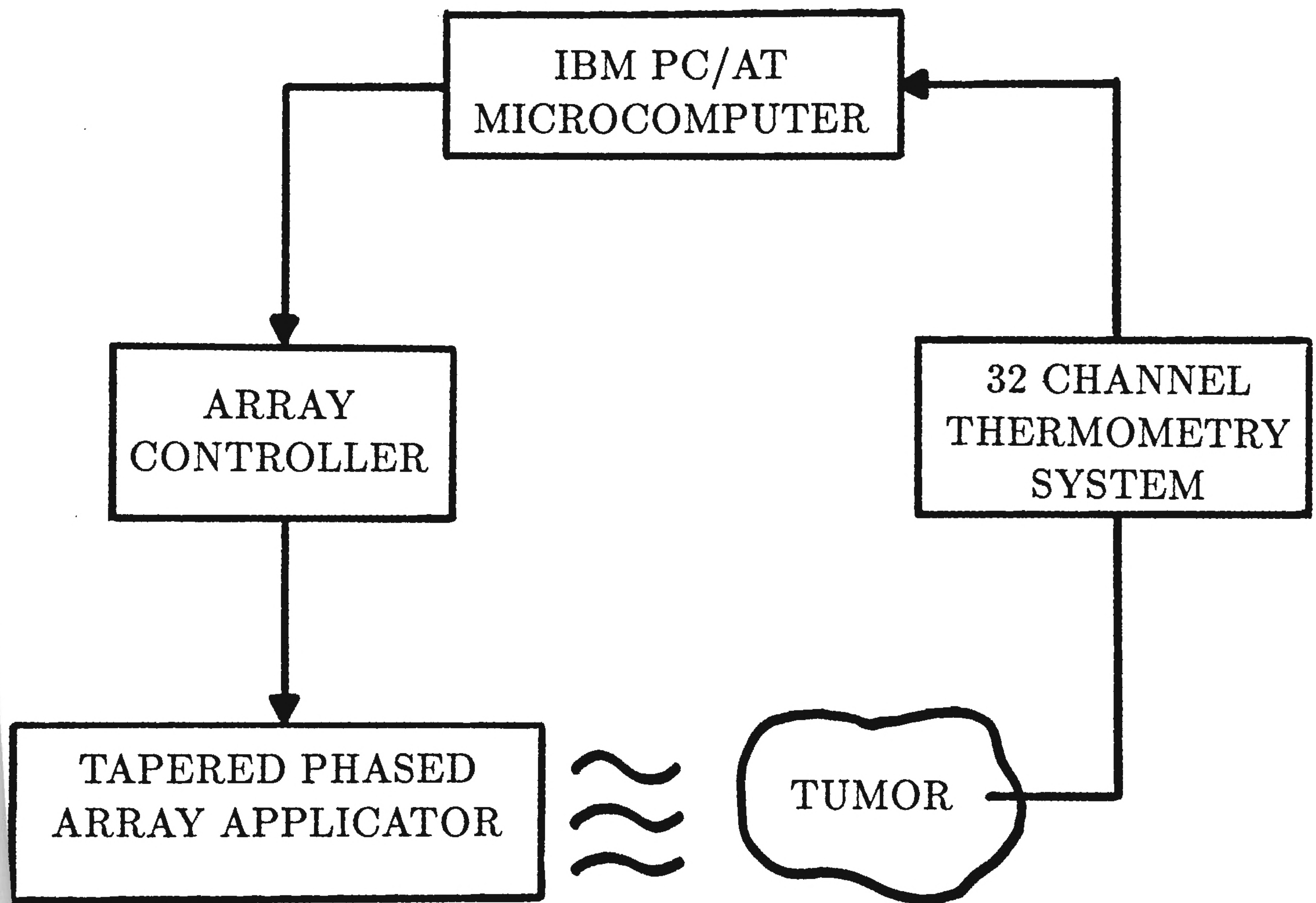

Figure 5. Block diagram of the TPA controller.

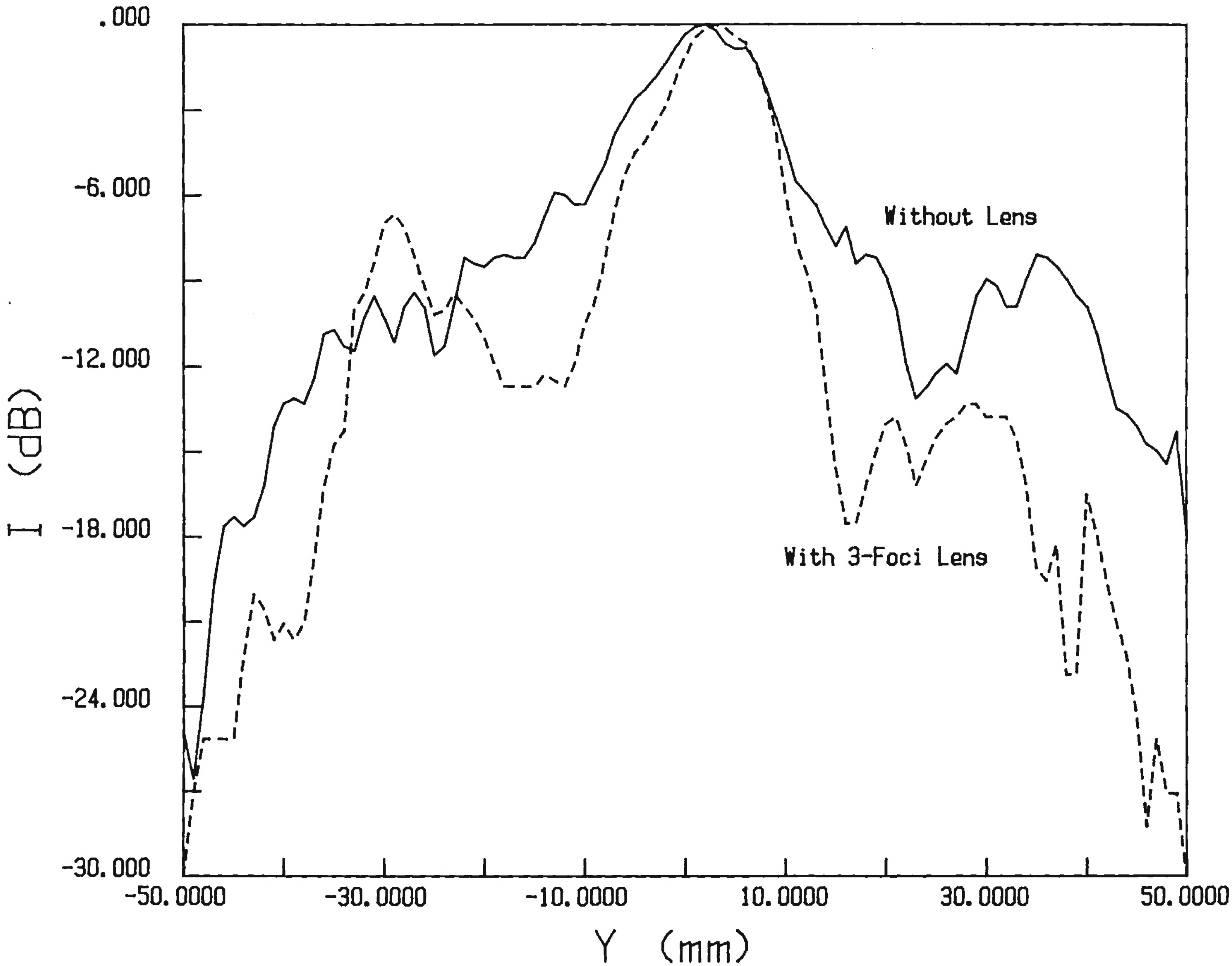

Figure 6. Experimental beam profiles of a 16 element TPA with an aperture of 101 mm by 51 mm operating at 435 kHz both with and without a lens with a radius of curvature of 100 mm. The profiles are at the electronic focal depth of z=100 mm.